THE OUTLOOK FOR THE PRODUCTION ENGINEER.

Presidential Address by E. W. Field, President, Birmingham Section.

IN offering the following remarks for your examination it should first of all be remembered that they express the opinions of the writer at the time of writing, but with the relative rapidity of development, particularly in the production engineering world, it is quite conceivable that some of your criticisms may cause a change of opinion.

No one, as yet, has been able to define a production engineer to the satisfaction of your Council as a whole. A description of a production specialist can be formulated in its relation to the work he is actually doing, providing a knowledge of the organisation with whom he is associated is obtainable, but nomenclature in the engineering profession is so diverse in its application that an assistant foreman in one works may easily be a more accomplished production engineer than the works manager of some other factory.

Realising the difficulty of actually inscribing in black and white a really all embracing sentence describing what a production engineer should be, perhaps the following somewhat disjointed review of some of the aspects of a production man's requirements will not be without interest.

Planning for Progress.

This should be viewed in its widest aspect. Not merely the progress of component parts of a mechanism through a factory, but the relation of planning in its outlook to modern life.

It is rather a singular fact that so many of our larger productive establishments are principally concerned with the intensive output of what may be termed "luxury products." By this is meant that their product tends to make human life more contented with its lot. In this connection we have only to take wireless sets, gramophones, aeroplanes, automobiles, sewing machines, magazines, reading books, electric and gas cookers, refrigerators, all the many electrical household gadgets, bicycles, furniture, vacuum cleaners, cinema films, to say nothing of the actual bodily dopes such as chocolates and sweetmeats in general, tobacco in its many forms, and stimulants, most of which require no eulogising.

Birmingham, April 18th, 1934 (Vol. XIII, No. 10. October, 1934).

Indeed, if one cares to go on in this strain it would appear that food and drink, with the means of growing, manufacturing and distributing them, are the only actual essentials with which the world is concerned. Reverting to the list of non-essentials you will, of course, say—what a poor world without them, with that statement one must agree and having accepted that fact it would seem that so long as any one inhabitant of this world is minus any one of them, so intensive production will go on.

This brings forward the question : Is there a saturation point ? Many of the world's leading economists have debated this point at some length without apparently arriving at any agreement, but even if we should arrive at that stage, where everybody has a wireless set, or indeed any of those items mentioned a moment ago, it is fairly safe to say that inventive genius will very soon make us all want some other luxury, perhaps not even yet thought of.

It is in this direction that the really thoughtful production engineer will sometimes cast his thoughts, for whenever he is inclined to think that his organisation has reached peak production—that is the time for him to realise how very much more remains to be done.

Routine.

The dictionary says that routine is " any regular course of action adhered to by force of habit without regard to altered circumstances or conditions." With this in mind it is obvious that no real production engineer can tolerate routine, for in this lies stagnation and a termination of progress.

So many of us perform the same daily round and accept blindly, the set of circumstances in which we find ourselves, whereas a little thought will always show an alternative which may lead to improvements, if only in the form of assisting our colleagues to a better appreciation of our own capabilities. You will probably tell me that works routine is an essential. If so, in reply, is the statement that your works routine does not conform to the definition in the dictionary—if it does you must be going backward because your circumstances or conditions can never be long the same in this age of progress, and anything done by force of habit can be improved upon.

Organisation.

Unfortunately, so far as most of us are concerned, the production engineers' aspect is all too frequently reorganisation. Without doubt, we all feel that if we could start with a clean slate the methods we are bound up in could be modified or improved out of all recognition. This is a lively thought because it indicates a sense of dissatisfaction, which in the long run can only point to progress,

providing, of course, that our dissatisfaction does not obsess us to the extent of giving the job best.

The organising, or even the reorganising, of any job should give nothing but pleasure, although work of this kind will always bring worries—a thing well done is always a source of intense satisfaction.

Distribution.

Whilst we can, as engineers, look round us and point with pride to a large number of well equipped and extremely efficient productive establishments, there is a weakness—that of distribution. Going a little wider than the subject of production for a moment, is it generally realised how production can be made or marred by inefficient methods of getting the product to the user.

In this connection, and all too often, there are too many middlemen handling the product in its journey from factory to the actual user, and any one with a knowledge of costs must deplore the ultimate price of many articles of everyday use. Indeed, it would be fairly safe to say that the manufacturer makes the least profit out of his wares.

Whilst the methods of production of practically everything have made such rapid strides in the last five years, it would seem to the onlooker that the science of distribution has lagged behind, and if our products are to reach all the potential world markets there is undoubtedly room for what may be termed distribution engineers, who should be employed by the manufacturers instead of leaving this important function to the free-lance middleman.

From this viewpoint it would seem that the productive world is inefficient and is striving to secure known markets without a proper appreciation of the potentialities of other parts of the world. It also brings the thought that as factories specialising on one type of product are now regarded as being clever and progressive, so ultimately must nations begin to specialise. We have at the moment huge areas devoted to nothing else but the production of wheat, others to the production of cattle, others to cotton, and it is quite conceivable that in time to come, the products of the world of engineering may become nationalised to something like the same degree. Tending towards this end we can see a certain trend in the partial grouping of certain industries to-day—Lancashire for cotton goods, the Midlands for automobiles, Yorkshire for woollens, North Stafford for pottery, Sheffield for steel, etc., and if you have any knowledge of other countries you will appreciate similar groupings in many instances. How far away are we from national and international specialisation ?

The large amalgamations and trading agreements, most of them too well known to require special mention, are an indication of things which will take place eventually on a scale we cannot, at

this time, fully appreciate. Closely allied with the distribution end of the business we get " service." Most of our up-to-date manufacturers are fully alive to this really important phase of their business, and with a few notable exceptions it is at this stage that the middleman—like the Arab—folds his tent and silently steals away.

An adequate service organisation is one of the best investments any engineering firm can make, and when a production engineer is planning for progress the possible calls from this department should be very much to the fore.

Whatever materials are used in the construction of engineering products there will always be wear and breakages, and it is in the replacement of these that reputations are made and lost. Rapid replacements are one of the crying needs of the engineering business.

Utilisation of Available Matter.

This can be looked at from many points of view, not the least important being the intelligent use of the human element employed in our factories. To this subject, many hundreds of hours of discussion have been given and many thousands of hours will follow. In a paper of this type only passing reference can be made, but it is up to the production engineer to realise the trust he must, of necessity, place in the hands of his operatives. Look at some of them to-morrow and think—there, but for the grace of God, go I. So long as this world lasts there must be subordinates, but the line of demarcation between top and bottom is not so great, and a little " milk of human kindness " goes a long, long way. So much can be done to make them happier and more comfortable in their work, and as time goes on and working hours get shorter there is a tremendous opening to teach them to use their leisure intelligently.

You will, in all probability tell me that this is up to the factory welfare department, but who ever heard of welfare departments until the production engineer made them necessary ? We have all heard quite a lot lately with respect to the shorter working week, but is there not another aspect which could be considered ?

Suppose the unemployment problem was, indirectly, attacked by means of a large increase in the rates of pay of those at present employed. At first sight this may sound very foolish, but you will all realise that the cost of labour in almost any manufactured article represents a very high proportion of its first price. With this in mind, if the labour cost is doubled there is no reason why the indirect charges (or overheads) should increase in the same proportion. Providing the increase in rates of pay is made universal it will naturally affect the price of raw materials, but here again it should not considerably increase the overheads, and there is apparently no real reason why manufactured goods should double in price because productive wages are doubled.

All this may sound, and undoubtedly is, very involved, but if the purchasing power of the masses is increased, it naturally follows that more employment will be found in meeting their requirements.

Constructive Criticism.

We are all inclined to be rather weak in this respect and often desist from expressing our real opinion because we feel that we might hurt the feelings of our friends and colleagues. With this in mind shall we make the first appeal in the negative sense—" Let us not be afraid of criticism." No production engineer worthy of the name should be afraid of discussing his projects, as it is only by a free interchange of ideas that progress can be secured, and oftentimes we " think " ourselves into a groove of the blind alley type, from which the only recovery is free and frank criticism from such of our associates who can look at the matter from a dispassionate viewpoint.

The broader aspect of this heading should make us realise how much of our lives, both working and leisure, is bound up in criticism. Criticism from this point of view allows us to select from a variety of suppliers the type of wireless set, or piano, or motor car, or tobacco, which most appeals to us, and the reason it does so appeal is because we consider the alternatives not so good, that is to say, we criticise by selection.

Every successful industrialist, or industrial organisation is absolutely dependent on the purchasing public appraising or criticising his product to his and their advantage, and it will not take you long to think back on one or two projects, launched with a flourish, which have failed because the critical public has considered the product inferior to an alternative type of article.

As production engineers, therefore, we have not only to think of our own internal works problems, but also the probable reaction of the user to what we are producing. If he or she does not like what we turn out for their needs, our competitors may get ahead of us through our own narrow-mindedness.

With this in mind it follows that all really good production men will familiarise themselves with what their competitors are offering and closely analyse the reasons for a competitors success or failure. Also, one should not forget the Jewish proverb—" There is much more to be learned from a failure than there is from a success," and also remember that no man worth his salt is afraid to make a mistake.

Training.

One of the greatest of the problems which face the production engineer to-day is the shortage of skilled mechanics, and unless some very big national move is made to remedy this, we are, as

a nation, in serious danger of losing our prestige as producers of quality goods.

Our Institution is doing all it can to encourage the younger members and prospective members to study and equip themselves for the higher positions in productive establishments, but there is very little being done to teach the future craftsman the basis of his selected trade. During the next session all our branches are requested by your Council to discuss as a common subject "The recruitment and training of craftsmen" and as a result of this there should emerge some scheme whereby the craftsman should be better appreciated.

A little thought on this subject may not be out of place in this paper, and to this end a question for your consideration may be formulated, i.e., should the craftsman be kept down in payment at what is colloquially termed "the rate ?" This naturally brings a second question—if so, what inducement is there for parents to apprentice their sons to the engineering business ? It must be very obvious to anyone who thinks for a moment that there must be dozens and dozens of operatives for every one position of authority, and sooner or later a higher rate of pay or incentive must be obtainable by craftsmen if we are to continue to get them, and so maintain our national standard of engineering. As mentioned a moment ago, this question will be thrashed out during our next session, and it is up to us to help to formulate some scheme whereby our continuity of engineering craftsman is secured.

This, of course, is a very wide aspect of the heading which commenced this section of the talk, and from the strictly production engineer's standpoint it is our own graduate section to which we now turn.

We, in Birmingham, have been given the honour of starting a special section for graduates, and the fact that the experiment has been so successful is not only due to those of your own Council who have taken an interest in the scheme, but also to the teachers in the technical institutions who have the foresight to appreciate the possibilities which graduate membership of our Institution may mean.

This success of this Institution in the future lies in a successful graduate section and, as one gets very little in this world unless something is given for it, it is up to the younger members to prepare to take the reins. You are all familiar with most of the gentlemen who have helped to make the Birmingham Section so successful, and you must agree that none of them have worked for self aggrandisement—on the contrary, they have all by word and deed worked for our improvement, and one sincerely hopes that they will long be spared to continue their efforts on our behalf. Let their example be a lesson to us all—let us all do something to help each other ;

do not be afraid to speak at our meetings, and give us all the benefit of your own experience because, as mentioned earlier, it is only by free and frank discussion and constructive criticism that progress can be made. There is no place in modern production for the "closed shop" or the secret process, our aim must be international, not parochial.

Imagination.

Imagination is a wonderful gift for those who have it, and conversely a terrible thing to those lacking the gift. Let us turn for a moment to the dictionary wherein imagination is defined primarily as "The mental faculty that apprehends and forms ideas of external objects" and secondly "The power of reproducing these mental sensations and of combining them so as to exhibit them vividly in expressed thought, in the form of figures, pictures, etc."

A man without imagination has no ambition, and can have no initiative. Most of us possess the first portion of the description of the word, i.e., mental faculty for apprehending and forming ideas, but too few of us have the second, the power of reproducing and combining these ideas so as to make them useful, and yet, possessing one of the attributes, why not a little intensive study to secure the other, and what better form of study than to exchange our experiences and by giving some portion of our knowledge, to secure in return some of the accumulated knowledge of the lecturers who address us from time to time.

From the production engineer's viewpoint it would seem that the dictionary description of imagination might be somewhat amended or amplified as follows—"The mental faculty which enables a man to practise the foresight which ultimately takes him to the head of his organisation."

Production engineering means thinking and planning ahead of requirements, and if your product is not ready and waiting for the purchaser at the exact moment he or she wants it, your competitor may reap the benefit of all your carefully prepared sales campaign.

Mention of sales campaign naturally turns ones thoughts to advertising, a modern weapon of aggression which often makes one purchase things one could really do quite well without. But without advertising many of us would be looking for work instead of actually doing it. One of the troubles of this country is our conservatism in our efforts to tell the rest of the world how good our products are. This may seem a digression from the viewpoint of the production engineer, but actually our lives depend upon the ability of our advertising staff to paint a true picture of the quality we are trying to put into our products. Closely allied both to advertising and actual production is the selling of the product by actual contact. A comparison of the engineering salesman to-day with his prede-

cessor of twenty years ago is all to the credit of modern times. Indeed, most of the salesmen of to-day have had considerable experience in the actual production of the article they are trying to sell and if they are to deal with production engineers it is absolutely essential that this type of man should continue to be "shop trained."

The engineering salesman is gradually becoming a consulting specialist and is usually well worth listening to because of his specialised knowledge of the subject upon which he talks.

Objects of the Production Engineer.

One of the first of these should be to raise the status of production engineering to a situation of greater national importance, and thereby to automatically improve the status of the country in world markets.

When one considers that it is only about twenty years since the term Production Engineer was first coined, it is rather amazing to realise the important position he has gained in modern shop management, and it would be a very severe shock, to industry at large, if production engineers ceased to exist. The trust which is placed in the hands of the production men in some of our largest productive organisations is really only a reflection of the appreciation of our class as a whole, and it would seem that sooner or later only the purely financial side can be kept from our control. Indeed, it does not need a great imaginative faculty to visualise the time when there will be a national "Director of Production" with a seat in the Cabinet. This peep into the future should not be taken to indicate that we are obsessed by the sense of our own importance, but rather that we are aware of national requirements, and the ability of some of our leading engineers to take an active part in controlling, what after all is largely a production country.

The importance of the engineering fraternity in times of national emergency is too recent in its proof to need emphasis and what has been done before can be done again a thousand times if the need should arise. Wars of the future will, we are told be affairs of gas and chemicals, but behind it all will be the production engineers and a nation at war is only as strong as its productive capacity for war materials. That we shall have no need to prove ourselves in this way again, however, is the wish of all of us.

The place of the production engineer in a world united in peace is, however, of even greater importance than his powers during a crisis, and the events of the last six years in Russia can give no greater point to this statement. The immense amount of engineering construction which has taken place is really too great for any single mind to appreciate, and whether the Russians have succeeded in securing 100 per cent. efficiency in their efforts or only 50 per cent., history will regard their effort as an outstanding achievement.

Here is a country which has appreciated and used the production engineer in a gigantic effort to raise the standard of living of a huge mass of people with a tolerable measure of success—first by importing production specialists from countries more advanced in the art of production, and secondly by assiduous study of the methods these imported engineers have evolved, and the re-application of them on a still larger scale.

Try and imagine the enormous progress which could be made in this country if only our Government could allocate to the requirements of industry a proportionate amount per inhabitant to that expended in Russia. And even if they did allocate such an amount the needs of our countrymen would still be unsatisfied, which merely shows that there can be no end to the production of manufactured articles.

National and International Co-operation.

All through the paper you will no doubt have appreciated the appeal for a wider outlook on production matters, and it may be that even our yardstick, by which potential members are judged, is all too narrow in its meaning.

For national co-operation, is not the production controller of a food factory as much an engineer as any of us ? Why should not the farmer who produces wheat or sheep or cattle be regarded as a production man ? If and when the time comes that we get national specialisation, men of these types will be regarded from quite a different viewpoint than they are at present.

Returning to the consideration of our comparatively narrow production engineer's outlook, there is still much to be done in the form of co-operation. Research work at the moment is almost confined to our universities, technical colleges, or to individual firms or amalgamated firms. In our own small way this Institution has progressed along the early lines of endeavour. Our discussions on rate fixing, standardisation, and several other subjects have ventilated many new avenues of approach to subjects of national interest and even importance, and we can look to the future to provide facilities for probing even deeper into the subjects which, whilst being common to us all, are at present largely regarded as internal works' problems.

Signs of improvement in the co-operative spirit are, however, to be observed, if only at the moment through the various committees formed by the British Standards Association. Efforts to secure standardisation are all tending towards a national ideal and it is with great pride that we can point to so many of our members who are associated with these committees.

The time may not be so far distant when specialised committees of the Institution may be formed to give a lead in the direction of

national research, and we may even come to the period when full time investigators will have to be engaged to effectively collate the valuable information which is to be obtained from our lectures and informal meetings.

WELDING—THE MODERN METHOD OF PRODUCTION.

Paper presented to the Institution, Manchester Section, by P. L. Roberts.

THE application of welding as a manufacturing process to engineering products has spread very rapidly in the last five years. It is used in every branch of this trade, and is being used more widely every day. The reasons for this rapid growth of the application are principally economical, though other factors are increased rate of production and a generally improved product. The considerable economic claims of welding probably have resulted in a more widely extended use during the present trade depression than would have been the case otherwise.

The Advantages of Welding.

From the production engineers' point of view the advantages of welding over other methods of manufacture, such as casting and riveting, are :

(1) A saving in the cost of production of 20 to 60 per cent. ; (2) a decrease in the time taken to complete manufacture of 50 to 300 per cent. ; (3) the universality ; (4) the simplicity of manufacture.

Dealing in brief with these points :

1. The saving to be effected over riveted structures. The efficiency of a welded joint is 100 per cent. as against 60 to 70 per cent. for a riveted joint. This increase in efficiency allows of a reduction in the sections of material used. The second saving is in the labour used, welding only requiring one operator, compared with two for riveting. In the case of weldings the saving is considerably higher on the larger work. Construction of a product from rolled steel sections by welding in place of casting from iron, eliminates the cost of a pattern, moulding and coring, which are always very costly for all but the small mass-produced castings. While the cost of rolled steel is twice that of cast iron, the ratio of strengths is of the order of 2.5 to 1, hence the weight, and therefore the cost of material, can be reduced in the same ratio (see "The Replacement of Castings by Weldings"—paper read before the Institution of Welding Engineers, February, 1930).

2. The majority of welded joints require no preparation, whereas riveted joints necessitate drilling and often reaming, or drifting of

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the holes. Hence the time taken to weld a given structure is less than the over-all time to rivet, and as there is only one operation and not two or three, the time inevitably lost *between* successive operations is also saved. The time saved in the case of weldings is very much greater. The largest of these can be assembled and completely welded in two weeks, whereas a casting for a similar purpose has to have a mould dug in the foundry floor, moulded and cored, which often takes weeks, and after pouring, a week or more may have to elapse to allow the casting to cool before it can be dressed.

3. The various processes of welding are very widely applicable to the manufacture of engineering products. The plant for any particular method, with the partial exception of the resistance processes, can be universally applied without modification for different sizes or classes of work. In the case of the fusion processes, too, the plant is extremely flexible and can be brought to the work instead of bringing the work to the plant.

4. Smaller articles can be formed by shearing and bending, and completed by welding in a jig, under simple mass production principles. Large work is readily built up from sections to size by automatic or band-operated oxy-acetylene flames. Assembly of the parts is done simply without jigs, complicated clamps, balls or screws, by using the process to tack the various parts together.

The Processes.

There are numerous processes available, but the most extensively used are metallic-arc and oxy-acetylene welding. A general lack of knowledge of the relative possibilities of these processes leads to much misapplication.

In endeavouring to select the most suitable process for a particular piece of work, the first choice falls on the most economical. If this is not adaptable to the particular work, then a less economical but practicable method must be used. Examplification of this will be given later. The cheapest method is resistance welding in any of its three forms, viz., butt or flash, seam, and spot welding. These are eminently mass-production processes. Their respective fields of application do not overlap, so that there is no confusion of choice here. Unfortunately, these methods are limited to work which can be brought to the plant and which can be readily handled, except in the case of the very smallest sections. A further limitation of spot and seam welding is that the material must be clean, and a lap joint must be used, with the thickness limitations given in the table. Butt and flash welding have the limitation of cross sectional area and of parts which can be butted end to end.

With these practical provisions the field of useful application is very considerably reduced, and where a product does not fall within

these, resort must be made to the less economical fusion processes. From the actual practicability point of view these processes considerably overlap, but economically there are definite limits on steel.

Generally then, oxy-acetylene welding should be used for thin sheet steel and metallic-arc welding for plate and heavy sections. The oxy-acetylene process is still the best fusion method of welding all the non-ferrous metals and alloys, so that here there is no choice.

The carbon arc may be used as an alternative to the metallic, on a number of limited applications, where distortion does not seriously affect the product, and where machining of the weld is not necessary. A great deal depends on the proficiency of the operator in the successful application of this process, and on this account is to be avoided unless considerable economical advantages are to be gained over the metallic arc.

The use of atomic hydrogen welding is extending. It covers both the oxy-acetylene and part of the metallic-arc field, but is more costly than either process. There are two distinct advantages possessed by atomic welding: the first is that, owing to the exclusion of atmospheric oxygen, the molten metal of the weld is always perfectly clean and free from slag—this enables the operator to observe the formation of any blow-holes, and immediately re-weld any such spot; the second advantage is that the weld has a very fine wave form and generally smooth finish. Since certain types of work have to be gas, oil, or water-tight, careful methods of testing the finished weld must be instituted. Such a test may take anything from 20 to 50 per cent. of the welding time, and is a dead load on the productive cost. Where defects occur, re-welding and re-testing is necessitated, and this may recur three or four times. Hence, as blow-holes are so easily observed during atomic welding, the number of leaks in a weld so made is very considerably below that of any other process, and the method is often used for this reason alone, as the time and labour saved on re-testing and re-welding more than offsets the extra cost.

The Application.

The conversion of existing methods of manufacture to production by welding requires experience, not perhaps so much in actually applying a welding process to a particular case, as in "spotting" the innumerable products which might be advantageously welded. The gradual extension, starting with the most obvious cases for modification, is the best method, and this brings the type of experience indicated.

Having decided to convert the manufacture of a certain suitable product to welding, the choice of process is the first step, and this should be done in line with the remarks already made. A compulsory limit may be set on this choice by the plant available. Obviously

plant cannot be installed specially unless there is sufficient work to keep it on full load. In the case of a factory where welding is not used at all and products are varied, the best process to instal at the start is either the oxy-acetylene or the metallic-arc (according to whether the work is light or heavy), as these methods are most universally applicable. When experience and confidence are gained more specialised plant, such as butt or spot welding apparatus, may be justifiably installed.

When the choice of process has been made, the preliminary manufacturing operations can be arranged. These will vary slightly depending on the type of welding used. For instance, oxy-acetylene and metallic-arc welding will preferably require butt joints and spot and seam welding joints. Shearing, kneeding, pressing, and bending, are particularly suitable preliminary operations. The fact that bending and pressing are cheaper operations than welding should not be lost to sight. For instance, a tank made by bending three corners and welding the fourth is much cheaper than one made from four plates welded at all four corners. Generally, such preliminary operations are straightforward, as any complicated shape is better built up by welding from simple sections.

Assembly of the component parts is almost without exception done most quickly and cheaply by tacking the parts together at intervals, with the actual welding process to be used subsequently. Spot welding is extremely rapid for this purpose, within the normal limits of the process. Where careful registration of the parts is necessary, assembly in a jig or by clamps is desirable preparatory to tacking.

The actual welding operation should be entrusted to a skilled operator. This is particularly important in the fusion processes, and unless done trouble will be frequently recurrent.

One or two examples will illustrate the conversion of methods of manufacture. A cast-iron bed-plate is easily superseded by one of rolled steel. A tray bent to shape from steel plate welded at the corners and inverted, forms the principal part; on this may be welded pads of steel which can be machined for the feet of the motor generator. Stiffeners of channel or box-section plates are welded on the underside immediately below the pads, and the bedplate is complete. This is a simple case, but it will be found that comparatively complicated castings resolve into a very few essentials which can be used by a greatly simplified welded object. In most cases this work would have to be done by the production engineer in conjunction with the designer, but the supersession of large castings is one of the most repaying of the possible applications for welding.

There is the example of a concrete mixer, previously made with a riveted frame, cast iron wheels and a cast iron mortar. Now the

frame is made from angle iron welded together, the wheels from a welded steel tyre with spokes of round bar welded to the tyre and a hub of steel tube, bored to size. The mortar is a steel pressing welded to the trunnions.

Steel smoke-stacks and chimneys are readily manufactured by welding from plate rolled to the required radius. Butt joints may be used throughout, thus avoiding the awkward overlaps which occur in riveted joints, where the transverse joints meet the longitudinal.

In the field of small articles sheet steel boxes and tanks repay most for early attention, as these are used for a wide variety of purposes. They may be punched or sheared from sheet, bent to shape and spot welded. If the box has to be liquid-tight, resistance seam welding must be used.

The modifications given of the lines along which the application of welding may run are those which the production engineer may follow in the course of his ordinary work. These may be extended to much more important work such as motor yokes, condenser shells, ships, bulkheads, and plating, steel building framework, bridges, etc., but this work will have to be done in conjunction with the designing engineer when the confidence of the factory authorities has been won for the modern method of manufacture by welding.

Discussion.

Mr. Ashworth: It gives me great pleasure to move a vote of thanks to Mr. Roberts for the able way in which he has given his lecture. I thought perhaps he would have given us one or two of his secrets. There is a lot of scepticism as to what welding is worth. For many years I was in the position of having to decide whether a job should be welded or not. I often had to take a risk and have never been let down. (I am speaking of the jobs that were never intended to be welded). I want to stand over a welding job and see it done if I have to pass it. Take two articles of equal merit, ready for sale. One has been welded and the other is a casting. The appearance is not going to sell the welded job.

The Chairman, Mr. F. W. Shaw: Appearance, after all, is a matter of fashion.

Mr. Tyson seconded the vote of thanks.

Mr. Roberts: I do not know that there are a great number of secrets about welding. I do not think there are any. If I have dealt with this subject in a rather general way, you must forgive me, as the lecture was only intended as an introduction to the subject. I just wished to give you a lead. If you are really going to get down to it, you must have a good deal more information, and I shall be only too pleased to correspond or discuss the matter with any of you. Regarding appearance, weldings certainly have a great many corners and look very square. It is difficult at first to get used to the appearance, as you miss the nicely rounded corners of castings. Those of us who are continuously in shops where these things are being produced by welding, soon find ourselves getting used to them. They have the merit of being very clean-cut and looking very business-like, and it is from that point of view the customer would rather incline towards them. There is nothing superfluous about them at all—they are simply made to do the job.

Mr. H. Shaw said that he would have been interested to have seen smaller jobs illustrated. He asked the lecturer whether he had any experience with welding in jigs, and how he allowed for the stresses in the piece being welded induced by the welding. For instance, a furnace frame, welded in a rigid jig, distorted when the furnace was heated, fracturing attached parts. After being welded in a jig designed to locate the frame members at incorrect angles, but so that it could deflect to bring the members to the correct angles as they contracted in cooling after welding no further trouble occurred.

Mr. Eckersley: Mr. Shaw has mentioned one or two points which have troubled me quite a lot. Regarding the distortion of

small parts in jigs, I have not had much experience in welding in jigs, and should imagine that if you come to use welding as a production method, the jig will get quite hot itself and tend to distort before the job starts to distort. Take thin sections that are narrow and long, and spot welded at intervals, you will have quite a lot of difficulty in avoiding distortion because, on account of the spot welds, you will get the heat spreading to the side of the weld and have distortion equal to the expansion and contraction. You get, say, one thin plate overlapping another to build up a thicker section. You cannot avoid distortion of the weld, unless you hold the pieces in such a fashion as to cool the weld as it is being made.

Mr. Roberts: It is interesting that both the last speakers should mention the one bugbear about welding, that is, the difficulty there sometimes is in accounting for distortion. A great deal depends on the process. I should like to know in the first case what process was used for welding?

Mr. H. Shaw: Oxy-acetylene welding, but we tried electric welding with similar results.

Mr. Roberts: You do get a great deal more distortion with oxy-acetylene, because the heated surface is larger. The heating is not nearly so local as with electric welding. There are many ways of overcoming the contraction with the average product which has not to be very accurately finished. When the product has to be finished to machine limits, it is good enough to build it up in such a way that it is built up steadily as a rigid structure which will resist contraction. What actually happens is that the metal stretches. It would be very difficult to join two flat plates by welding without producing some distortion or even putting a wave in the work. One way is to start welding at the centre and work towards the ends. It is very difficult to keep plates flat when you weld. The best way is to assemble these before welding. Take part of the tank. You assemble the whole thing by tacking. Having tacked up and made a reasonably rigid structure, weld up. If there is risk of increased distortion, then you can use "alternate" welding. That is, weld every alternate foot. Having been built up like that as a rigid structure, it will resist distortion to any appreciable extent. It is chiefly a matter of keeping distortion within such limits as not to be readily seen. It is chiefly a question of appearance. If a thing is designed properly, the distortion is only going to account for an amount which does not matter so long as you cannot easily see it. You may simply get local stretching depending on the process. Quite frequently you will find that if you are getting excessive distortion when using oxy-acetylene, you can turn to the metallic arc as a solution. Regarding distortion of jigs, you can, of course, overheat your jig and get distortion, which means that the jig is not made properly.

MR. F. W. SHAW asked a question regarding the possibility of distortion stresses reacting after the parts are assembled.

MR. ROBERTS : There is a certain amount of risk in that direction. Do you mean that distortion might occur later after a period in work ? There is very little risk of that. I think you mean distortion might occur after having machined the structure. There is the same risk as with a casting but much reduced if the metal is not strong enough to resist the stress. In the case of stress-contraction coming into play after a period, I have certainly never met with such a case, and it is not likely to occur unless the part is working at a fairly high temperature.

MR. P. S. CROOKE : I have a very similar problem. (A large plate resembling a ribbed surface plate was illustrated on the blackboard). Another problem was the difficulty of welding two tubular pieces end to end, a certain number being rejected for imperfect welds.

MR. ROBERTS : In the first case, it is agreed that any distortion should take place immediately after welding, so that if it is serious, you would have to modify the construction. If there is any subsequent distortion due to locked-up stresses, it should occur in working. If it does occur, it means that you have locked up too much stress in the weld ; you have not stiffened the work sufficiently, and that means increasing the size of your stiffening bars. Welding stresses alone would not set up any subsequent distortion. You might alter the bars to angles or tubes. These would be more difficult to weld, of course. In the second case, the most satisfactory method would be flash welding, but that means a special plant. In that case an oxy-acetylene flame or atomic arc would be better. With atomic arc welding any tendency to oxidise would show up during the operation, and you can get a very clean surface which would machine without showing any defect. Metallic arc welding would not be satisfactory for that.

MR. CROOKE raised a question concerning the two parts having different carbon content.

MR. ROBERTS : There is less likelihood of blow-holes forming if the carbon contents of two materials are more nearly alike. If you increase the carbon content of the piece having the lower carbon content, you will stand a better chance of getting a clean weld.

MR. CROOKE : With flash-welding I sometimes get a bad joint. Would it be better to polish the ends ?

MR. ROBERTS : They should be cleaned. Any impurity will increase the difficulty and cause some blow-holes to form. The trouble rather suggests that you are not pushing out enough metal.

MR. CROOKE : Would it be an advantage to chamfer the other way—inside rather than outside ?

Mr. Roberts : I think you will find that you will get much better results by leaving the ends square or, alternatively, by leaving more metal on the outside than the inside. You will get good results with square ends. It is the best way because then you get uniform pressure over the whole section and a more uniform weld. Square ends are better. The other methods are only a get-out.

A Visitor : I have had a little experience with welding. I have seen some very good examples, and the finished article often comes out much better than the casting it replaces. I am sorry Mr. Roberts did not give us some information about salvaging operations. I think there is a great deal of room for organizing the salvaging of castings by welding. If properly done, a big saving could be effected. Can Mr. Roberts give us a few examples as to how he would decide whether an article is suitable for welding or not ?

Mr. Roberts : The repair of castings by welding is a subject in itself, particularly when you have to deal with iron and aluminium castings. As a matter of fact, I did not dare to suggest to production engineers of a really efficient factory that there was ever any need to repair anything. The subject is one for a whole evening's paper. At the moment I cannot give you any figures. It is, of course, desirable to keep a check on the cost of welding in the case of new castings, because you will perhaps find there is a tendency to cover up carelessness, by welding quite small castings which are mass produced. It is castings that you have only one or two of that are worth repairing, or castings with small blow-holes or not badly fractured. The question is rather outside the scope of the paper.

Mr. F. W. Shaw : What system would the lecturer recommend for welding defects in a large steel casting which could not conveniently be removed from the machine—a large gear being cut, for instance ? If the gear were used as one electrode, would it be necessary to insulate the job or the machine ? Or, would it be necessary to employ the carbon-arc ? Generally, in welding, the metal about the weld was so hard that the teeth could not be re-cut but had to be dressed to form by chisel and file. Could this hardening be avoided ? Can high-carbon steels, say 0.8, be welded together or to low-carbon steels without hammering ? Can the carbon content be higher in the presence of chromium or nickel ? Was it practicable to weld nickel-chrome steels ? Were magnetic or X-ray systems of inspection workshop propositions ? When the end of a bar or plate was welded to another bar or plate so as to form a tee, did the bars or plates unite or were they merely held by the fillets ? If so, the strength of the weld would be simply that of the fillets. Can electric welding, as can oxy-acetylene welding, be employed in the field for building structures ?

Mr. Roberts : It is undoubtedly difficult to repair cast steel

without getting a hardening effect, and this is due, of course, to the carbon content of cast steel varying between 0.3 and 0.4 per cent. The difficulty is that the material round the weld is always harder than the adjacent metal. The remedy is to play the oxy-acetylene flame on the hard portion, bring it to a red heat, and allow it to cool slowly. With regard to welding high-carbon steel, this is not very satisfactory. You can probably go as high as 0.8 with care without getting blow-holes, but if you increase above that, you will almost certainly get them. You can only safely go up to 0.8 with any process. You can certainly close up blow-holes by hammering. If the carbon content is as high as 0.8 you must hammer it red hot. It is quite good practice in steel castings to hammer up after the weld is cold to close up the blow-holes. A carbon content of more than 0.5 in a high-grade steel or chromium-nickel alloy increases the difficulty of welding. Again, you get a tendency to form blow-holes, and I do not know of any way in which you can avoid that. Is it necessary to have high carbon content with nickel-chromium steel? It depends on what you want to use it for. If you are having trouble, it is very likely due to the chromium content. To arrest oxidisation of the chromium, the best method is to exclude the weld as far as possible from the air and cool it as quickly as possible. I think the most practical way of testing welds is by examination. There is no magnetic or X-ray apparatus which can be successfully installed in the works, these being but laboratory appliances. Undoubtedly the most satisfactory method is a fairly rigid inspection and occasional progress inspection, i.e., to jump down on the welder occasionally when he is not expecting it. Concerning welding by filleting, the weld did not extend far into the plate, but since the fillets acted at a greater distance from the neutral axes, they offered as great a resistance as would plates directly welded. Welding, but not oxy-acetylene, can be very satisfactorily applied for building structures. I know of certain buildings fixed by oxy-acetylene, but the difficulties are considerably increased because the contraction stresses are high. The metallic arc is undoubtedly the best for that work, and moreover, can be carried right into the field.

The vote of thanks to Mr. Roberts was put to the meeting and adopted with acclamation.

MODERN FOUNDRY PRODUCTION METHODS.

Paper presented to the Institution, Western Section, by J. J. Sheehan, A.R.C.Sc.I.

THE subject matter of this paper may be dealt with most conveniently under three general headings, and heading that should appeal particularly to the production engineer: (1) Engineering Design; (2) Engineering Control; (3) Chemical and Metallurgical Control. These divisions have their sub-divisions and may be tabulated as follows:

(1) Engineering design of:
- (*a*) General lay-out.
- (*b*) Special machinery.
- (*c*) Parts fabricated so as to facilitate production.

(2) Engineering control of:
- (*a*) Foundry maintenance.
- (*b*) Pattern equipment, core room, melting, inspectors, and moulding equipment.
- (*c*) Special operations, time studies, etc.

(3) Chemical and metallurgical control of:
- (*a*) Incoming raw materials, i.e., pig iron, fuel, refractories, sand, core compounds, mould dressings.
- (*b*) Manufacturing process—metal melting, core baking.
- (*c*) Maintenance of standards in final products, e.g., chemical composition and physical properties.
- (*d*) Investigation of defects.

It is proposed to confine our attention only to the problems of a cast-iron foundry, considering them to be mainly typical of the others, and to consider repetition castings to be the business of the foundry. The problem of foundry production, as in any industrial process is the reduction of waste of human effort, material, and fuel through the use of better methods.

Engineering Design—(*a*) General Lay-out.

Under this heading we will first consider the general lay-out of a modern foundry, and being limited by the scope of the paper, will start our considerations after delivery of raw materials to the

Bristol, January 12th, 1934.

stock yard. In sequence the operations are melting, moulding (which includes core making), cooling, and cleaning. Previous to the development of the Moders mechanised foundry these operations were almost entirely dependent on manual labour. The pig iron and coke were at one time actually wheeled in barrows up an inclined gangway then charged by hand to the furnace. The molten metal was taken in hand ladles to the moulding floor, the casting allowed to cool overnight on the floor, and cleaned on the floor.

Now production engineers in consultation with the foundry managers have revolutionised this simplicity, either by partial mechanisation, moulding machines, overhead sand conveyor, gravity mould conveyors, and mechanised shake-out, or by complete mechanisation and straight line lay-out, yard crane, monorail for molten metal, mould conveyor, core conveyor, cooling conveyor, and cleaning room equipment.

The importance of efficient handling, and of even this handling reduced to a minimum, cannot be over emphasised in connection with foundry work. Various estimates have been made of the amount of materials handled, results have ranged up to a figure of 250 tons for every ton of finished castings. This figure helps us to realise the necessity of keeping in mind a straight line lay-out. The distance these materials are carried must not be overlooked.

In the case of a cupola, a pulverised fuel rotary furnace, and an electric furnace, the cupola deserves most of our attention. It is still the most widely used melting unit, mainly for its initial cheapness and its low cost of operation. The cupola is a stack furnace, the raw materials are charged at an elevation and sink through the melting zone, to be delivered in the molten condition at the tapping and slag spouts at the foundry floor. Getting the raw materials from the stock yard to the elevated charging floor is the first mechanised operation of a modern foundry. Pig iron and scrap, coke, and limestone are conveniently handled by a yard crane fitted with an electro-magnet and grab bucket.

The stocks are placed in smaller auxiliary bins at the charging floor level and weighed from these, then charged by hand to the furnace. This operation has minor modifications, such as weighing in the stock yard into a charging bucket and elevating the bucket by crane into the cupola, discharging the bucket through a drop bottom or by tipping.

Our next consideration is the transport of the molten metal from the cupola to the moulds. Provided the quantity required per unit cast does not exceed 2,000 lbs., a monorail system is the least expensive and the most efficient, particularly in conjunction with a mould conveyor system. Every effort should be made by the foundry engineers to attain direct pouring from the carrying ladle

to the moulds. For large ladle quantities an overhead travelling crane is necessary.

Next in sequence comes the mould conveyor. Many considerations determine the ultimate choice in design for this unit, such as the size of the casting and the amount of production required. Useful facts to keep in mind are to provide an ample length of pouring station and knock-out station. This presupposes of necessity that ample provision has been made at the moulding station, which of course is the business end of this conveyor.

At this stage mention must be made of perhaps the most important single factor in a modern mechanised foundry, i.e., synchronisation of operations. Where maximum output is required for a given installation :

Cores must arrive on time at the moulding station.

Metal must arrive at casting temperature and on time at the pouring station.

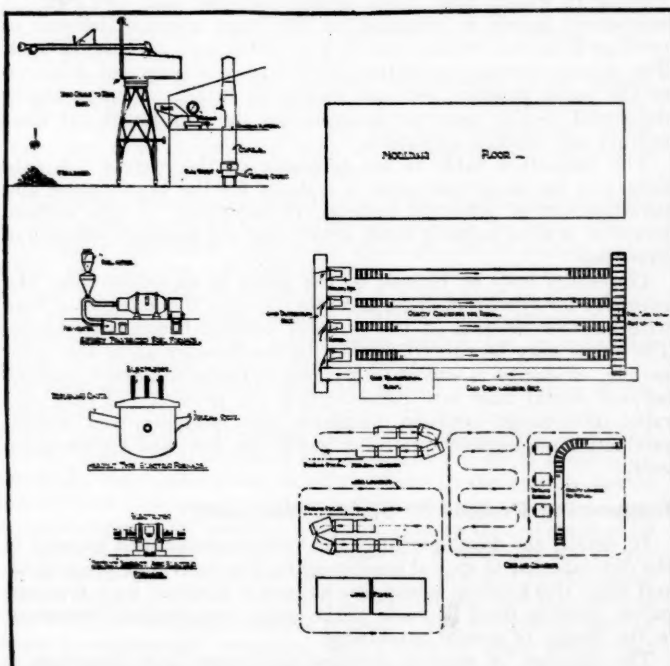

Fig. 1.

Moulding flasks must be returned from the shake-out to the moulding station regularly.

Moulding sand must be always available in the overhead bins.

An auxiliary conveyor of interest is the casting cooling conveyor. If space is a major consideration this assumes added importance. It may be installed anywhere overhead or even outside the foundry building. The "take-off" is at the shake-out and the delivery in the cleaning room.

The core knock-out should be placed en route and in an elevated position to allow of gravity disposal of the core sand to the dump wagon or to the core recovery plant.

Our next consideration is the cleaning room, this lay-out does not offer many difficulties but opinions differ as to the best method of cleaning with tumbling barrels or shot blast. Perhaps the problem is best met by a dual installation, this is certainly so in the automobile industry, where the variety of castings is considerable, varying in weight from a few ounces to more than two cwt. A convenient layout is indicated on the chart showing delivery of castings from the cooling conveyor to the barrels or blast cabinet. The cleaned castings are fettled on gravity conveyors and delivered to the water pressure test and inspection tables. A more highly developed cooling conveyor incorporates the core knock-out blast cabinet and fettling operations.

The inspection table is the terminus of the system. A subsidiary of the inspection table is a depot for the examination and investigation of defective castings, consideration of this section, however, is more suitably dealt with under the heading—Control of Processes.

Conveyors may be likened to the gears of an automobile; the necessity for synchronisation becomes obvious, if one is out of time with another, friction at the point of contact becomes excessive. The simile may be carried further, in the foundry as in the automobile, efficiency is served by a choice of ratios and every foundry lay-out should take into consideration the necessity of easy and rapid interchange between maximum and minimum and normal production requirements, in other words top, low, and intermediate gear.

Engineering Design—(*b*) Special Machinery.

In detail, the development of the modern mechanised foundry is the development of special machinery for the individual operations, and while this heading would provide ample material for a separate paper, mention must be made of the main considerations necessary in the design of special machinery.

The function of modern foundry equipment is to maintain a steady flow through the plant from raw material to finished product.

The machine that performs this operation best should receive the first consideration. A good illustration of the preference given on basis is provided by the melting machinery. The cupola or shaft furnace as a melting machine has many inherent defects from a metallurgical point of view.

The materials are charged at a distance from the melting zone and in their travel may easily get into combinations not desired in the final mix. The metal materials are in continuous contact with the fuel and as a consequence easily pick up impurities from it. The rotary furnace and the electric furnace are free from these defects and have the additional advantage of providing metal at a higher and more easily controlled temperature. Yet the cupola holds a more prominent place in the foundry and developments are rather in the direction of improving the cupola than in developing the rotary or electric furnaces to the requirements of continuous production. It must be borne in mind that it takes three rotary furnaces to provide a continuous flow of metal to the moulding conveyor, one furnace charging, one melting, and one pouring. This is true, also, of the electric furnace.

A development giving the combined advantages of the cupola and an electric furnace and which would be enthusiastically welcomed by the foundry manager and the metallurgist and should receive the most careful attention of the production engineer is illustrated in the sketch on page 532.

Continuous production is maintained in the shaft *B*, contact with the fuel is minimised by keeping the tap hole of the shaft furnace continuously open then there is no accumulation of molten metal around the coke bed. Mixing errors due to irregular travel down the shaft are corrected in the container *A*, which must be sufficiently large to hold three metal charges. All the advantages of high temperatures and of good temperature control are provided by making the container *A* an induction furnace.

Another unit that should profitably attract the attention of the production engineer is the sand mixer on the moulding system. At present this operation of mixing and re-conditioning the used sand from the shake-out is anything but satisfactory. To be thoroughly milled and thus make available all the bond in the sand, a double Roller Muller is necessary; this is not a continuous operating unit, two are necessary to maintain a flow of sand to the overhead sand hoppers and constant attention is necessary to alternate the operation of the mixers. Again the continuously operating paddle mixer does not impart a rubbing action to the sand drains and thus re-coat them with the bonding materials present. The problem then is to design a continuously operating Muller type or other mixer that will give the rubbing action necessary, and avoid also the necessity of constant supervision. This is but another of the many foundry

problems awaiting the attention of the production engineer. Under this sub-title of design of special machinery there is material of many papers and much work.

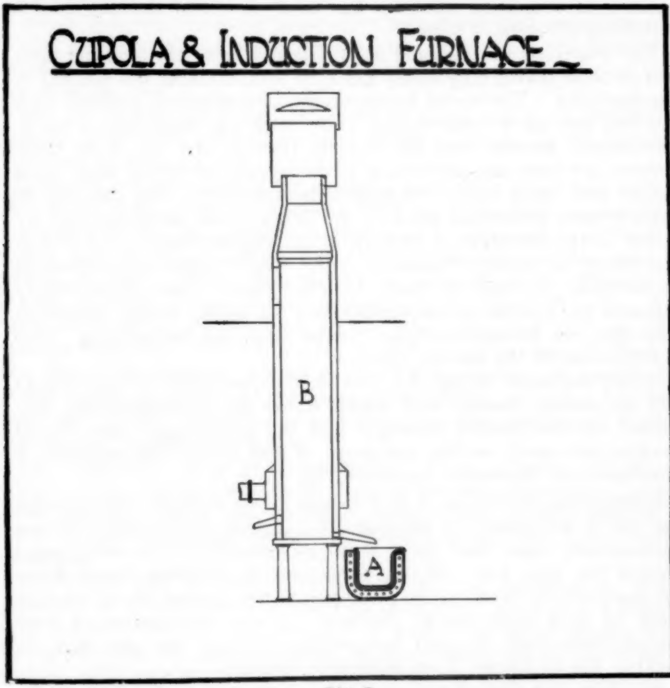

Fig. 2.

Engineering Design—(*c*) **Parts fabricated so as to facilitate production.**

This heading illustrates admirably the necessity of co-operation between the engineer and foundry man, the necessity exists right through any development in a modern foundry, but this heading best emphasises it.

An example from automobile production will help us to realise this :

The cylinders and water jacket were originally designed as one casting, the crankcase as another. The production engineer has an inspiration and decides to increase production by designing a unit that will incorporate the two. One casting where two were pre-

viously necessary. The economy is immediately evident. The resultant changes in foundry practice were not at first so obvious.

A tabulation of the consequences of this change is perhaps the best method of telling the story :

(1) The *cylinder block only* being a comparatively compact casting, could be cast with a metal with a very wide temperature range and a similar wide range of composition with consequently less necessity for close supervision of control of these items. A metal of the following composition was found adequate :

Silicon	1.6 to 2.0	per cent.
Phosphorus	0.4 to 0.7	,,
Manganese...	0.4 to 0.8	,,
Sulphur	0.1 max.	,,
Total Carbon	3.0 to 3.5	,,

(2) *Cylinder block and crankcase combined.* This combination casting had to fulfil two contradictary conditions. It is necessary to maintain hardness and closeness of grain in the cylinder bores and softness and ease of machining on the flanges and thin walls of the crankcase. In an effort to obtain this desired effect an interesting sequence of consequences resulted.

(1) To run the thin walls the pouring temperature had to be raised.

(2) This increased temperature gave openness of grain in the thicker cylinder walls and spongeness or drawn metal at changes of section.

(3) To prevent this spongeness the phosphorus content of the iron was reduced. This called for a new grade of pig iron from the blast furnace now known as semi-phosphoric pig.

(4) This lowering of the phosphorus content rendered the metal less fluid and combined with a silicon content of 1.6 per cent. gave white and unmachinable iron on the flanges of the crankcase. Then the lower limit of silicon content was eliminated and the allowable range narrowed.

(5) The lower phosphorus had a further effect. Low phosphorus irons pick up more carbon in the cupola. This higher carbon content gives open metal.

(6) Steel was then added to the cupola charge to lower the carbon content of the iron and has resulted in the present so called semi-steel cylinder irons of the following composition :

Silicon	1.9 to 2.1	per cent.
Phosphorus	0.27 to 0.32	,,
Manganese	0.8 to 1.00	,,
Sulphur...	0.1 max.	,,
Total Carbon	3.2 to 3.5	,,

The foundry man or the metallurgist was not responsible for this change, it was forced upon them step by step by the ambition of the production engineer to make two blades of grass grow where only one grew previously, not that the change is not a distinct advance; it has widened the foundryman's experience and metallurgical knowledge, and the engineer's respect for his difficulties, and the engineer's knowledge of design, and has emphasised the necessity for co-operation. As right through this sequence of changes, design was also changing and accommodating itself to the altered conditions—thin walls were increased, cylinder walls reduced, large bosses eliminated, radii increased, change in section minimised. The foundry where co-operation existed accomplished the change with a minimum of expense and trouble. It must be realised, however, that while the designer endeavours to make the sections of any casting as uniform as possible and to arrange change of section to be as gradual as possible, the possibility of securing these different sections in one piece is the very reason for the casting itself.

Engineering Control.

Under this general heading we will first consider the necessity for good control of foundry maintenance. This must be a distinct department and under the supervision of a competent millwright. A consideration of the previous remarks under the general heading of Modern Foundry Lay-out will show that this is absolutely essential. The lay-out is designed to maintain a steady flow through the foundry from pig iron to finished casting, but the function of the lay-out and the synchronisation of the conveyors is rendered futile by a mechanical breakdown at any single point.

Take any one simple breakdown and consider the consequences. A breakdown in the air valve to the cupola will serve as an example. Should the breakdown take ten minutes to rectify, that ten minutes spreads itself right through the foundry and is multiplied by the number of men made idle by the breakdown, furnace chargers, tapping-out men, ladle men, skimmers, moulders, shake-out men, and the production lost spreads through the overhead on the foundry, and the non-productive labour is also that much less effective. The moral effect on the workers of irritating minor breakdowns should not be overlooked. The production rhythm is broken and time is lost in regaining it. Numerous other examples suggest themselves but the foregoing should be sufficient to emphasise the necessity of efficient engineering supervision. This supervision should be extended to cover foundry equipment such as pattern, core room, and moulding equipment. It is desirable, however, to have available a distinct type of supervision for this section of the modern foundry.

Pattern makers trained to work to fine dimensions and tool makers make the best operators and supervisors of this section. No casting can be more accurate than the pattern which forms the mould and the cores that are assembled in it, and no core can be more accurate than the box in which it was made. It is difficult to overstress attention to dimensional details, and the necessity of constant attention to maintain the equipment accurate. Core boxes wear easily from the constant abrasion of the core sand, core dryers and plates warp from the intermittent heating and cooling through the core ovens. Apart from this insistence on accurate equipment is the necessity for careful inspection and gauging of each individual core and this again requires accurate gauges. A point often overlooked in organising this supervision is that the more accurate the foundation operations are performed and supervised the less labour is required on the subsequent or intermediate operations. To illustrate, if the core box is accurate and the core plate flat, the core inspection will have to reject or rectify less than one per cent. of the cores examined for such defect as sagging, or breaks, or bad ramming, while if the core box or plate is warped, every core from this equipment has to be examined and if possible rectified and the minor defects often then escape attention. Should any defective cores reach the moulding station there is the temptation on the moulders' part to use them so as to maintain production, particularly when it is realised that on subsequent examination the defect is traced to the core shop and the moulder cannot in justice be held responsible.

These remarks on supervision of foundation operations may be applied generally. Accurate weighing of the furnace charges is the first insurance against inaccurate metal composition. Careful attention to the measurements of the sand volumes maintains constant moulding sand conditions. Indeed, if these operations are inaccurate no amount of further attentions will rectify the consequences.

Engineering Control of Special Operations.

Mainly to conserve time this heading must be extended to cover also metallurgical control and indeed all foundry operations as such. These subjects could be considered in detail with much interest.

The control of special operations is the basis of all foundry progress. It is possible perhaps to have a good foundry without it, i.e., a foundry producing a good product economically, but it will only be a good foundry for a period, as it is without the means of producing a *better* product *more* economically. This control of special operations is the research department of the foundry and its extent and effectiveness is a real measure of executive ability and foresight.

Preferably it should be a separate organisation within the foundry and under the immediate control of a moulding foreman.

Its functions are to continually improve products and practice, and all the non-productive assistance and knowledge should be at its disposal, and all the technical staff should be encouraged to be interested. Consideration of a simple problem will make the point of these remarks clearer. A complicated casting is being made mainly with oil sand cores, the product is good and the temptation is to leave well enough alone. A progressive executive will leave well enough alone on the productive line, but under this research department developments will be initiated.

An examination of the production costs and a time study of the operations will reveal that the major cost items are the oil sand cores. It is decided to eliminate, say, a base core and substitute green sand mould, during the experimental period many difficulties arise. The green sand washes away where the dry core stood up to the flow of the metal, increased ramming and jolting of the mould produces a condition in the sand that will enable it to resist this action of the metal but results unfortunately in such a dense sand that the gases in the sand cannot escape and blown castings then result. The laboratory may then be called upon to produce a moulding sand that may be rammed hard and yet remain permeable to the escaping gases.

This is possible by having a sand consisting mainly of rounded uniform sized grains, free from fines and small grains which tend to pack into the spaces between the larger grains, and preventing the escape of the evolved gases. The moulder and the chemist have now made possible a considerably cheaper production method for this particular casting. The chemist has, however, added in the process something to the cost of every other casting by the need for a special moulding sand. The engineer then takes up the problem and solves this added difficulty by the installation of a simple sand recovery plant, giving new sand for old. This sand by series of screens removes all fine and broken sand grains from the used sand and returns the good grains to the moulding system. The net gains are a saving in core sand, core compound, labour in making the core and inspecting it, and its assembly in the mould and a cheaper moulding sand for all castings, and this very important accidental advantage that a round grain sand flows better into the mould and requires less jolting to make a satisfactory mould, thus increasing production and saving power. Altogether this investigation has increased production, cut costs and added considerably to the knowledge of everybody concerned, and placed that foundry so much ahead of the foundry willing to leave well enough alone.

Chemical and Metallurgical Control.

Under this heading the first consideration is the control of incoming raw materials, pig iron, fuel, refractories, sand core compounds, mould dressing and general foundry supplies such as chaplets, sprigs, and core wires. Remarks on this subject may be taken in conjunction with the remarks on the control of foundation operations as this is the control of foundation materials. The more care taken at this stage the less trouble with resultant materials and operations later.

The greatest single factor in this control is undoubtedly rigid specifications of requirements. Take as an example coke for the cupola furnace specified carefully as follows: Material desired is coke suitable for use as fuel in foundry cupola. Material should conform to the following analysis:

Carbon	88 per cent. or over.
Ash	6 per cent. or under.
Sulphur	0.8 per cent. or under.

Size: Not more than five per cent. should pass through a sieve having $2\frac{1}{2}$ inch square holes. The strength of the coke shall be determined by "Shatter Test," which shall be carried out, as follows:

Forty-two lbs. of coke that is retained on a two inch screen to be dropped four times from a height of six feet. The shatter indices are the percentages retained on two inch and $1\frac{1}{2}$ inch screens. Shatter indices to be not less than: 88 on two inch, 95 on $1\frac{1}{2}$ inch. Shipments will be subject to inspection for chemical and physical properties.

Now, copies of this specification sent to foundry companies leave them in no doubt as to what is required. Should their product not come up to specification, they usually refrain from quoting or sending samples and the foundry is saved the trouble and expense of examining what is undoubtedly useless. Samples sent to specification should, however, be carefully examined. The best and the cheapest finally selected, in connection with this final selection of coke an interesting point to consider is the shatter index. It is quoted in the specification and interpreted means, an index of the ability of the coke to stand rough handling.

Supposing two cokes were equal in every other respect but price and shatter index. The lower priced coke having also the lower shatter index. Then a re-calculation of price should be made on the shatter figures, as it is evident that after the coke had been handled from truck or ship to charging floor bins, and from bins to cupola, there is more of the higher index coke remaining intact and useful, and more of the lower index coke shattered to breeze and useless.

All the receiving inspection of the foundry materials must be based on identical lines—that is rigid specification and careful examination to ensure that both sample and consignment conform to specification. Even such details as chaplets should be brought to specification and a blue print of dimensions given to the suppliers. (Chaplets are tinned details used to keep the cores in position in the mould while the metal is still molted.) In the case of chaplets it is most important that the metal should be protected from rust and the best way to ensure this protection is to specify that the details are tinned with a definite thickness of tin and with tin of a definite purity.

A careful consideration of this system of specification and examination will show how necessary it is to efficient production. It avoids the danger of always buying the cheapest which is the natural tendency of the buying department, and ensures the best and consistently the best at competitive prices. If it is found through the research of the foundry or laboratory that a cheaper material will satisfy the demands of a particular operation then the specification may be altered to meet this new situation, but the alteration must be made with knowledge and authority.

Its help in maintaining consistence may be illustrated by the specification for pig iron. The cupola furnace charge consists of proportions of pig iron, returned scrap and mild steel. The composition of the return scrap is known from the hourly check analysis on the metal and the composition of mild steel is well defined. The only source of variable composition is the pig iron. The important element, silicon, may vary to the extent of one per cent., and if the proportion of pig iron in the charge is 50 per cent. then the variation due to the pig in the resultant metal will be 0.50 per cent. If then a limit on pig iron of 0.25 per cent. is demanded by the specification the variation is 0.12 per cent. in the final melt, which is well within the limits demanded by any type of cast iron or even any type of special purpose iron. This narrower limit makes the return scrap analysis more consistent and again helps the final composition.

The variety in the quality of refractories makes it imperative that the services required should be accurately specified and as accurately checked. This is a matter that is often overlooked but the ease with which refractories may be tested and the economy in the use of the best materials should encourage more careful examination.

Two simple tests are readily carried out and are very instructive—one to put the refractory brick through a cycle of heating and rapid cooling to test resistance to spalling, the other to melt iron in a cavity in the brick and measure the depth of penetration of the metal and metal oxides. This subject of specification has led to a

completely new departure in the matter of moulding sands, or rather has been the inspiration of a new development.

Specifications were established for moulding sands giving very particular requirements, and usually based on moulding sands that had proved satisfactory. Now in examining consignments to these specifications it was found that considerable variations occurred, and variations which were beyond the abilities of the suppliers to control or rectify. It was found that the variations occurred in the deposits or pits.

There was often a variation from pit to pit and often from depth to depth in the same pit. A careful analysis of these sands, however, showed that the variation was due to such impurities as silt, to deficiency in the clay bond or to excess of clay bond.

Further research showed that this variation could be avoided by building up or synthesising a moulding sand. There are many deposits of pure silica sand of uniform grain size, these are combined with clay products having the desired moulding properties of high binding powers and refractoriness and a moulding sand results with well defined and easily controlled properties. A further development of this practice is the recovery of the used core sand as the basis of the synthetic moulding sand. The outline of the practice is a selection of a core sand or sands of suitable purity and grain size, so that when the sands have functioned as cores they may be freed from dust and fines, a refractory binder added and incorporated in a mixer.

The equipment necessary is a set of vibrating screens and a mixer preferably of the Muller type. The economy of this recent development is immediately apparent, a moulding sand is obtained at the cost of screening used sand and adding binder. These examples do not exhaust the advantages arising from control of incoming raw materials and others will readily suggest themselves to engineers who are already familiar with the system of specification.

The Technical Control of Manufacturing Process.

In the foundry this is indispensable to good production and indeed helps us to realise the variety of information required for the efficient working of the modern foundry. The laboratory is mainly responsible for this control and an examination of the working of it in the metal melting department will illustrate also the general scheme.

The control begins with the specification and examination of raw materials already mentioned and one may say restarts the moment the charging floor labour handles the raw materials. In hand charging of a cupola furnace, the procedure is as follows and for the following technical reasons.

Limestone is charged on the coke to flux away the ash of the

burnt coke. Scrap steel is charged on the coke bed and in the centre of the cupola to get the benefit of the highest temperature steel having the highest melting point. Pig iron is charged around the circumference of the furnace so that the big section of the pig may be warmed through by the ascending hot gases, these gases rising more easily around the circumference.

Scrap is charged in the centre and on the steel. The scrap is of smaller section than the pig iron and is raised to its melting point more easily. It also has a lower melting point than the steel and is liquid sooner and in flowing over the underlying layer of steel washes it and dissolves it.

Following the control to the tapping spout of the furnace, i.e., to the metal in the molten condition. To ensure complete mixing of the components of the charge the well of the furnace must be kept full, and should have a capacity of at least three charges. This thorough mixing maintains the composition constant. However a constant check is also kept on the resulting melt by the laboratory.

Complete chemical analysis is taken regularly as well as a determination of the following physical constants—transverse strength, deflection, shrink, depth of chill and Brinell hardness, figure and tensile strength at less frequent intervals.

Pouring temperature is maintained between limits determined and found suitable for each particular type of casting. This determination is conveniently carried out directly by a radiation pyrometer or indirectly from the time of setting of a constant weight or measure of metal. A continuation of this control sometimes under the independent supervision of the inspection department is the routine testing of the chemical and physical properties of the finished product. One casting a day or one out of so many is selected for complete laboratory examination.

Investigation of Defects.

Finally, comes the organisation of a system that is most painful in operation but most salutary on effect—the investigation of defects. All scrap and defective castings should be listed daily and summarised weekly. The daily scrap should be collected at one location grouped according to type of defect examined carefully to determine the cause and then steps taken to rectify the fault.

The foreman or charge hand responsible for the defect should be brought to this location and given visible evidence of the carelessness of his supervision. Every care should be taken to fix the responsibility accurately as at this inquest some wonderful excuses are produced, some of them are worth enumerating. Here is a list taken from a technical journal. The fiendishly ingenious feature of these excuses is that they carry just sufficient truth to appear plausible.

The defect is caused by :

Dull metal,	Plumbago no good,
Bad facing sand,	Bars in cope loose,
Dirty metal,	Monday morning,
Chaplet blown,	Boss didn't tell me,
Core blew up,	Pattern was warped,
Metal too hot,	Metal came too late,
Shop too dark,	Metal came too soon.
Shop too light,	Rat went down riser,
Metal too hard,	Labourer fell over mould,
Cores too hard,	Metal ran down rat-hole,
No vents in cores,	Dog walked across mould,
Flask burned out,	and many, many, more.

However, in each of these cases and in front of a competent examiner the excuse maker is faced with this question—" With all this fore knowledge why did he not either refuse to use the materials, or, file a formal protest before using them ? "

I have come to the end of this paper but not by any means to an end of the subject—I am conscious of many omissions, my first consideration, however, in presenting this paper to the Institution of Production Engineers was so to write it and to present the view " That the wood was not obscured by the trees." If I have succeeded in arousing the interest and sympathy of the production engineer in the production problems of a modern foundry, then the writing of this paper like virtue is its own reward.

Discussion.

Mr. Knapp: I would like to ask our lecturer his opinion with regard to fuels for melting—coke versus electricity, versus gas and oil. What does he consider the best fuel, and what are the particular advantages of the particular type of fuel he considers best?

Mr. Sheehan: I presume that Mr. Knapp means using these fuels from the point of view of quality rather than any other consideration. I am certainly of the opinion that the electric furnace gives the best quality. It is so much easier to control from the temperature point of view, and the heating medium does not come into contact with the melting metal. Coke, of course, is very economical but the metal comes into direct contact with the coke and any impurities in the coke are picked up in the melt. The melting of non-ferrous metals, of course, is done out of contact with the fuel, but the metals come into contact with the gases from the fuel and metals of this class such as aluminium are inclined to pick up gases when they are heated. With electric melting you do not get gases in contact with your melt. I therefore consider the electric furnace the most efficient melting unit when you consider quality and quality alone.

Mr. Hayward: The lecturer made reference to the recovery of sand, but he said nothing about oil sand for cores. How much of this is it possible to recover and how do you remove the oil from the recovered sand?

Mr. Sheehan: As I said in my paper with regard to the recovery of sand after the knocking out of the moulds, or from the cores, it often happens that more moulding sand is recovered than can be used conveniently for moulding, and the remainder can then be used up in the core sand. With regard to the getting rid of the old bond from recovered core sand, this depends a good deal on the amount of bonding the core has received. If the sand has been recovered from cores that have required a good deal of bonding then it is necessary to burn out the old bond. In fact this is nearly always necessary because this bond mixed with the new bond reduces the permeability of the sand very considerably. With some cores up to 50 per cent. of the old sand can be recovered, and it will be seen that the saving in cost due to proper means for recovery of old sand can be very considerable. Small plants taking sand in lots of from 350 to 500 tons, can recover a large proportion of their sand and use it again at a cost of from 7d. to 1s. per ton for moulding sand and 4d. to 5d. per ton for core sand, whereas good new sand will cost them 35s. to 37s. per ton for moulding sand and 13s. to 14s. per ton for core sand according to distance transported.

Mr. Weeks: With regard to furnaces, does the lecturer think

the electric furnace is more convenient for an iron foundry? In his paper he refers to the container, I take it that by this he means the same thing as we call the receiver, and we find that drawing off the metal into this has a cleaning effect. Does the lecturer consider this weighs against the electric furnace by removing part of the disadvantages of the coke furnace?

MR. SHEEHAN: On this type of work, which is straight line production I think the cupola comes out best because it gives a continuous charge. The electric furnace cannot do this and therefore you need three electric furnaces to give a continuous supply of metal, one coming up to heat, one charging, and one pouring. The reservoir does give a better mix, but the drop in temperature caused by its use is apt to give trouble, as if it is at all big it will often make it impossible to pour castings without mis-runs and cold shuts. The reservoir should be electrically heated, preferably by an induction furnace, or possibly by arc. I have always advocated an induction furnace and I think that the best way of heating the reservoir, and I am waiting for a combination cupola and induction furnace.

MR. SAVILLE: I would like to ask one or two questions with regard to patterns and the method of dealing with increases and decreases in production. I assume that a master pattern is made in wood, and several metal patterns are made from it. Now, if a foundry wishes to turn out 20 castings an hour, with one pattern this would only allow three minutes for ramming, setting cores, etc., per casting. If one assumes that the operation would take nine minutes, you would require three patterns for the above rate of production, and any speeding up of production would require a proportionate increase in the number of patterns. In cases of production the number of patterns required would be reduced, and also in that case what should be done with the surplus labour in the foundry. Also should one keep spare men standing by in case of an increase in production? It also seems to me that in cases of great multiplicity of patterns a good deal of expense would be entailed in cases of modifications to the castings. Even a minor modification would often mean new metal patterns throughout.

MR. SHEEHAN: As my questioner says the first pattern is a wooden pattern and from this pattern many metal patterns, dependent on the production required, are made. If you want to speed up production or to vary production, then the number of patterns in use must be varied to suit. A very convenient plant has been adopted in America for dealing with the problem you raise, They have a turntable with five or six patterns on it, fed by a sand slinger, and the moulds are made up on this table. If you require say 500 castings your moulds are made up on five patterns, if you require 300 then they are made up on three, or for 100 they are made up

on one only. With regard to surplus labour this is a very difficult problem in any business. If you have big production you want a lot of men, and with low production it is very difficult to find alternative employment. I think this is a problem which must be dealt with on the spot by an efficient executive, and as I said in my paper the executive should endeavour to arrange in the organisation for peak production, ordinary production, and low production. The multiplicity of patterns is necessary if you want a variation in your production, and more patterns will mean better patterns because then spares are available to go back to the pattern shop and be reconditioned.

MR. WOOD : The lecturer did not mention work on or the use of heat-treated cast iron, nor centrifugal castings, nor permanent mould castings. I thought permanent mould castings were being used extensively in motor car work especially. With regard to the reservoir, does he mean you tap three heats into the reservoir ? In steel work a huge container is used which has a paddle to mix several charges. Is there any paddle on the reservoir he describes ?

MR. SHEEHAN : When you come down to heat-treated castings you are coming on to castings for special requirements. The heat treatment of cast iron is a recent development in that direction and is very successfully carried out even in production foundries. As a matter of fact I believe I was the first to introduce heat-treated push rods for automobiles in this country, and there is no added difficulty in the mass production of castings for heat-treatment. We found that if you required a special composition metal for heat-treated castings, as undoubtedly you do, there was no difficulty in using that special iron in general work, and the result was not that the general foundry production interfered with the metal for heat-treated castings, but that the general foundry work was improved in the effort to get metal good enough to be heat-treated. I did not mention centrifugal castings because I was nervous in going into details particularly in the presence of production engineers. Permanent metal castings are not developing so rapidly as it was supposed they would ten years ago. You have no limit to the shapes you can make with sand moulds, and they are much more flexible and capable of rectification than the permanent metal moulds.

I could have gone into more detail in my paper on some of these special cases, but wrote my paper merely on general lines in order to stimulate your interest as engineers in the foundry. Mr. Whitehead said in his remarks that at one time he looked on the foundry as not much of a place, and I wrote my paper to convince you that there are more problems in the foundry than anywhere else in the works. I believe the foundry is the one place where the engineer should not be afraid to try and introduce engineering

methods. With regard to the reservoir, in steel foundries, I know, huge reservoirs are employed, and the reservoir I mentioned is a modification of these of rather smaller lines large enough to contain three charges. By using a reservoir of this size your chance of getting an incorrect mix is divided by three. No paddle is used for mixing in this reservoir.

Mr. Key : With regard to acceptances of moulding sands, would the lecturer specify limits of the size of particles, also what would be the maximum and minimum limits of Clay Bond he would accept as being in keeping with a good moulding sand ?

Mr. Sheehan : The suitability of sands depends altogether on the type of work the foundry is engaged upon. Generally a good foundry man is anxious to get sand as permeable as possible. That is, as open as possible to get the gases away from the metal, but he is limited by the finish he requires on his castings. If you have large grain size, open sand, the gases can get away more easily but you get very rough castings, so that you depend on size of grains for the finish you require and look for sand which will give the maximum openness with that finish. In non-ferrous work, such as aluminium, your temperatures are not so high, therefore the volume of gases is not so great as with cast iron and steel, and you are therefore able to use the finer grain sand to get the finer finish which is usually required on that class of work. I don't know if you are familiar with the system of grading according to the British Cast Iron Research Association. Screens are used of 30, 40, 50, 60, etc., up to 200 to the inch. If a sand that gives you 75 per cent. on the 60 screen gives you the required finish then you see that the supplier maintains this standard. It is very difficult to find natural deposits which will give regularity of size and bond and that is why synthetic sand is coming so much into use. Grain size is not the only consideration, you have also got to take into account the strength of your sand. The control of sand can conveniently be divided into three heads, these are : Strength, permeability, and moisture content.

Mr. Newman : How does the lecturer consider a foundry could be generally organised in connection with a cupola running six or seven various iron analyses per day or per hour ?

Mr. Sheehan : It is the business of the production foundry manager to minimise the amount of irons used in the foundry. It does not make for efficiency and it is not an indication of efficiency if with a range of castings you have to use different types of analyses for these castings. An efficient foundryman with the help of the analyst should be able to arrange for one type of iron to cover a wide range of castings. A cupola can be made with a capacity as low as 2½ tons per hour. If you have not got a capacity of 2½ tons per hour it does not pay to mechanise. In the mechanised foundry

you must have sufficient production to justify the mechanisation. The minimum is about $4\frac{1}{2}$ tons to five tons per hour, in an eight-hour day about 40 tons a day.

MR. HIGGINS: With regard to the conveyor system, is this operated by power or entirely gravity operated? I am not quite clear as to how the castings are cooled, it appeared to me that they were just carried round in the atmosphere. Would it not be better to have a low shed to hang them in, with a fan at the end? What use is made of nickel cast iron in the modern automobile? Finally, what is the effect of mechanisation on the class of labour employed in the foundry?

MR. SHEEHAN: The conveyor systems are of many types and the type has to be decided by the type of work you are doing. If this is very heavy then the tray type has to be used. If it is light then the pendulum type can be used. This consists of a chain with a pendulum hanging from it. This type of conveyor requires very little power to drive it. It is usually driven electrically and the speed can be regulated by a variable speed motor. In every efficient foundry you must have allowance for a peak period, average, and very low production periods. These conveyors are a later development of the gravity conveyor. With reference to the cooling conveyor, the castings are just allowed to cool naturally. You could cool more rapidly by creating a draught, but you must remember that the castings are very hot and by giving off their heat to the air around them they cause this to rise and so create a system of air currents round them. So I do not think the necessity for a fan arises, or for any auxiliary cooling system. There have been very many developments in cast iron, that is by the addition of nickel, chromium, and alloys of copper and silicon. If these are used for special purposes their use is justified, but if they are used as a "cure all" their use is not justified, because good general purpose cast iron is as good as alloy iron if properly made and properly controlled. Nickel is added very often to cover up defects in hardness which could be controlled easily otherwise. It must be remembered that one per cent. of nickel costs as much as all the rest of the cast iron so that it must have good justification for its use. The type of labour developed by the mechanised foundry is a rather peculiar one. The executive of it is usually taken from the moulders from the older firms, while the operators of the machines are usually general labourers. There is one thing you should remember, while the old type of moulder is usually very skilled, he is often slow to adapt himself to modern methods, so that in the development of a modern plant it is well to select young men of very definite technical abilities to be trained as foremen or executives. The mechanisation of the foundry gives the old type of moulder a chance of getting into a better position by making an

executive of him if he takes the opportunity and it is up to him to get a general engineering outlook and improve his technical knowledge. If he does not do that he deserves to stay where he is.

Mr. Wood: There is one further question I should like to ask. Does the lecturer consider that the fully mechanised foundry can hold its own with the development of parts fabricated by welding?

Mr. Sheehan: In reply to this question I would repeat what I said in my paper, "That the possibility of securing various sections in the one piece is the justification for the casting." It would take a lot of welding to build up a cylinder block. There is a justification for use of welding and that is that you use a minimum of material. In a casting you have a certain amount of material and machine this down to requirements, and the modern engineer has to compromise between building up and cutting down. As a matter of engineering practice I think it will be a long time before casting is going to be ousted by welding or forging.

Mr. Gadd: I think this paper has been very enlightening to many of us in this respect: There is a widespread belief that a mass produced article must of necessity be an inferior article. The description given in this paper of the care and control of materials at every stage of manufacture, which is necessary for modern production methods, has dispelled this view. I was interested to hear the lecturer's remarks in regard to foundry experimental work. I think it would be beneficial if this could be done in a separate building, although in some small foundries the research and experimental work may have to be done in the production foundry. I would like to know whether the cost of the electric furnace compared with the cupola is likely to be competitive. I should think that in the aluminium foundry the cost of working an electric furnace would be prohibitive owing to the high specific heat of the aluminium.

Mr. Sheehan: With regard to electric furnaces compared with the cupola, you are quite correct; there is a variation in the cost dependent upon the material required, and the possibility of using the electric furnace at all, is dependent entirely upon the cheapness of the source of raw material in cast iron work particularly, you can take borings and swarf from the shop and shovel this material into an electric furnace at a cost of 8s. to 12s. per ton, and you get from it material at least equivalent in condition to the material from which the borings were drilled, as a matter of fact you get material in better condition. If you compare this with the price of raw material for a cupola, in cylinder work, of 85s. to 160s. per ton, you have a big margin, but in aluminium work as you say you are dealing with a metal which is not easily melted cheaply, and melting by electricity is not reducing the cost of the material.

Mr. Kenworthy: Mr. Sheehan has referred in his paper to collaboration between the design, production, and foundry departments. A lot can be done in this respect. The designer should consider methods of moulding and positions of spotting faces when designing castings. This will enable receiver jigs to be used for inspection utilising the same spotting faces as for production. He mentioned, also, the question of inspection. It is interesting to know that in modern foundries, inspection of cores is carried out and this should considerably reduce scrap. In most foundries the question of core inspection is left to the core maker himself, and the question as to whether the core is satisfactory is decided when the casting is inspected. It would be interesting to know whether the inspection carried out in the foundry is controlled by the same head as production inspection, or is it controlled by the laboratory, or by a combination of both. There would appear to be two branches necessary, one controlling the quality of the raw materials used and the other the quality of the work produced. Is it considered desirable to inspect finished castings in the foundry or in the raw material inspection department and confine inspection of the product in the foundry to core and process inspection.

Mr. Sheehan: Collaboration between the engineer and the foundry man makes for efficient production. If the engineer wants a certain casting he puts it up to the foundryman to make. The foundryman then perhaps says, if you make a certain modification I can reduce the cost. Perhaps this can be done without any consideration and the engineer agrees. If it cannot be done without consideration the progressive engineer will confer with the foundryman as to the possibility of making the modification and will not turn it down without proper investigation. With regard to the inspection of cores this is under the control of the foundry executive or foundry foreman. He is responsible for the percentage of scrap made in the foundry or due to foundry defects and one of the ways to control his scrap is to see that the material is correct dimensionally. He ought to try to get machine shop or preferably tool room accuracy in his jigs, core boxes, and plates. You cannot make a core more accurate than the box. The inspection should be divided between three departments: The foundry executive for work in the foundry; the inspection department generally, to ensure accuracy; the laboratory to ensure quality of material. If the undertaking is not large enough to have these three divisions then it is convenient to combine them into one, but these three main heads of inspection must be considered.

Mr. Whitehead: What is the percentage of inspection against production, that is the number of employees in the mechanised foundry you describe? Also, what are the limits of pouring temperatures when producing cylinder work?

Mr. Sheehan : With regard to the question of inspection, the higher the percentage, the better the product, and I would say that in a modern mechanised foundry the percentage of inspectors is as high as five per cent. of the total number employed. It can be as low as two per cent., but five per cent. is a figure it is very difficult to get below. This five per cent. should cover the inspection that comes under the head of the foundry executive. The inspection carried out in the inspection department will be combined with their other work, and the laboratory can control the quality of the material in conjunction with their other testing of the factory's products. With regard to the limits of pouring temperatures on cylinder blocks. These are unfortunately getting closer. The requirements for modern cylinders due to increased piston speeds and alloy pistons which increase the lapping action on the cylinder bore have resulted in very close limits in the composition of the cylinder block and in close limits in pouring temperatures. For a satisfactory cylinder block in green sand the limits in pouring are between 2,300° and 2,500° Fahr. Above 2,500° the metal burns into the sand and you get a tendency to shrink, below 2,300° you are inclined to get cold shuts, and at these high temperatures a limit of only 200° is very close.

Mr. Weeks : In his remarks about the inspection department with regard to bringing the culprit to book the lecturer gives a list of excuses, but there was one he missed out, " It never happened before." He says you should have the wasters listed daily and bring the culprits to task once a week. With a very large foundry it may not be possible to deal with your wasters at once, but I should think it would be better if this could be done at least daily. In our foundry when the moulds are knocked out we have the foremen handy and the castings are examined at once, any wasters found, and the culprits dealt with on the spot.

Mr. Sheehan : I am quite in agreement with you. It depends on the size of the foundry whether you can deal with your wasters right away. If you can do so, well and good, but if you are turning out 1,250 cylinder blocks a day you cannot have a man round every waster. The only thing to do is to have your wasters set aside with the reasons for their rejection, and you can hold an inquiry at stated times when the culprits can see the visible evidence of their own carelessness. How often you do this and the exact procedure depend entirely on the size of the foundry.

ANNUAL DINNER AND ANNUAL GENERAL MEETING.

The Eleventh Annual Dinner of the Institution is to be held at The Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2, on Friday, November 16th, 1934. The Dinner will be preceded at 6-30 p.m. by the Annual General Meeting, and the Reception at 7-0 p.m.

Sir Walter Kent, C.B.E., President, will be in the chair supported by Sir Herbert Austin, K.B.E. and Sir Alfred Herbert, K.B.E. Among the guests will be Dr. Bergin, M.P., Parliamentary Secretary, Board of Trade; Mr. L. H. Pomery, President, Institution of Automobile Engineers; and Provost Lang, President of The Machine Tool and Engineering Exhibition.

ANNUAL REPORT

and

ACCOUNTS

For the Year ended 30th June, 1934

To be presented at the

ANNUAL GENERAL MEETING,

16th November, 1934,

Connaught Rooms, London,

at 6-30 p.m.

THE INSTITUTION OF PRODUCTION ENGINEERS.

BALANCE SHEET AS AT 30 JUNE, 1934.

LIABILITIES.				£	s.	d.
Sundry Creditors				215	7	10
Subscriptions received in advance ...				11	14	0
Sir Herbert Austin Prize Fund				52	10	0
Building Fund				130	0	0
INCOME AND EXPENDITURE ACCOUNT:						
Balance at 1 July, 1933	£1032	18	8			
Add Excess of Income over Expenditure for the year	243	6	11			
				1276	5	7

ASSETS.				£	s.	d.
FURNITURE, FITTINGS, AND PLANT:						
At cost, less amount written off:						
Balance at 1 July, 1933	100	17	1			
Additions during the year	25	7	7			
	126	4	8			
Less amount written off	29	13	4			
				96	11	4
INVESTMENTS:						
£1448 14s. 10d. 2½ per cent. Consolidated Stock at cost...				1040	4	3
(Market value £1153 11s. 2d.)						
SUNDRY DEBTORS:						
General	145	17	10			
Subscription arrears ...	70	0	0			
				215	17	10

	£	s.	d.				£	s.	d.	£	s.	d.
					CASH :							
					At Bank...		325	14	11			
					In hand		7	9	1			
										333	4	0
	£1685	17	5							£1685	17	5

AUDITORS' REPORT.—We have audited the above Balance Sheet dated the 30th June, 1934, and we have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs according to the best of our information and the explanations given us and as shown by the books of the Institution.

34-36, Oxford Street, London, W.1.
11th October, 1934.

(*Signed*) C. H. APPLEBY AND COMPANY, Auditors.
Chartered Accountants.

(*Signed*) S. CARLTON SMITH, *Chairman of Council.*
(*Signed*) ROBT. HUTCHINSON, *Chairman, Finance Committee.*
(*Signed*) R. HAZLETON, *General Secretary and Treasurer.*

THE INSTITUTION OF PRODUCTION ENGINEERS.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30 JUNE, 1934.

DR.	£	s.	d.	CR.				£	s.	d.
To Salaries	824	9	9	By Subscriptions for 1933-34 :						
„ Rent, Lighting, Heating, and Cleaning	147	0	2	Received	£1820	6	0			
				Outstanding	70	0	0			
„ Local Section Expenses	348	5	2					1890	6	0
„ Printing, Postages, Stationery, Telephone, and Certificates	191	10	3	„ Interest on Investments				30	3	3
„ Printing, Postage, and Stationery—Journal and Bulletin	524	9	6	„ Receipts from Sales and Advertisements of Journal				713	16	6
„ Staff Travelling and Expenses of General Meetings	74	3	8							

	£	s.	d.		£	s.	d.
„ Legal and Professional Charges, Insurances, and Income Tax	159	10	11				
„ Library	20	11	5				
„ Examinations	16	13	4				
„ Annual Dinner	13	11	4				
„ Subscriptions written off	41	0	0				
„ Amount written off Furniture, Fittings, and Plant	29	13	4				
„ Balance, being excess of Income over Expenditure	243	6	11				
	£2634	5	9		£2634	5	9

ANNUAL REPORT FOR 1933-34.

To be presented by the Council to the Annual General Meeting, London, 16th November, 1934.

Membership.

The membership at the end of June, 1934, was as follows:

Honorary Members	3
Ordinary Members	445
Associates	33
Associate Members	422
Graduates	104
Affiliates	15
	1,022

Two hundred and four new members were added to the Register during the year. Deductions, through lapse or resignation, were 43, and through death five. It is with much regret that there has to be recorded the death of Mr. K. M. Sloan, a prominent member of the Glasgow Section Committee, and also that of Messrs. J. Harrison, J. Johnson, J. Macleod, and T. S. Rumph.

Finance.

The Accounts for 1933-34 show that income exceeded expenditure by £243 6s. 11d., and that the finances of the Institution are in a very sound condition.

New Local Sections.

During the year a new Local Section, with the title of Western Section, was opened at Bristol, and preliminary steps were taken to open a Southern Section with headquarters at Southampton, and another Section at Leicester. It is the policy of the Council to extend the number of Local Sections so that facilities offered by the Institution can be available to the largest possible number of production engineers. Before the end of 1934 there will be thirteen Sections, compared with three in 1929, and it is hoped that two or three others will be added during the coming twelve months.

Growth of Activities.

The growth of Local Sections brings with it a corresponding growth in the Institution's activities. The number of lecture meetings held last session was close on one hundred, compared with between 20 and 30 five years ago. The attendances at lectures have been very satisfactory. In October alone over 1,500 attendances were recorded.

Council and Local Section Committees.

A large part of the success of the Institution's work is due to those members who give their time to the various Council and Local Section Committees. Returns published in *The Bulletin* show how well members attend to these onerous duties.

Section Hon. Secretaries.

It would be impossible for the Institution to function efficiently on its present basis without the assistance afforded by competent Hon. Secretaries in the various Local Sections. It has been fortunate in finding members capable and willing to undertake the task. Thanks are tendered to them all. Mr. R. J. Mitchell, formerly a Member of Council, has kindly undertaken the Hon. Secretaryship of the Yorkshire Section in succession to Mr. J. Horn. Mr. W. A. Purves succeeds Mr. W. M. Pudge as Hon. Secretary of the Luton Section, Mr. Copping replaces Mr. C. Green in the Eastern Counties Section, and Mr. C. J. Swain has taken over from Mr. W. S. Harris at Coventry.

Memorandum and Articles of Association.

The revisions to these were completed and adopted during the year. The most important changes were in the ages for certain membership grades.

Graduateship Examination.

The Syllabus for this has been extensively revised. In future the examinations will occupy two full days instead of one. The entrants for the 1934 examination numbered 59 of whom 43 passed.

Sir Herbert Austin Prize.

The winner of the Sir Herbert Austin Prize for 1934 was Mr. C. K. Hughes, Birmingham.

Social Functions.

The Council note with satisfaction that Local Sections are steadily extending the number and variety of their social functions. Over 200 attended the first Dinner Dance arranged by the Birmingham Section, while the attendance at the latest Luton Section Annual Dinner was 214. None of these functions entails any charge on the finances of the Institution.

The Journal.

The expansion of *The Journal* continues. Volume XII contained 664 pages of reports of lectures and discussions, compared with 418 pages in Volume XI.

Advisory Committee to City and Guilds Institute.

Institution representatives have during the year attended meetings of our Advisory Committee on Fitters', Turners', and Machinists' Work, and also meetings of the Moderating Committee. Disappointment has been expressed at the small number of entries for the Course. Members are reminded that in the interests of the Institution they should support the work of the Committee. Copies of the syllabus can be obtained from Headquarters.

Public Secondary Schools Headmasters' Committee.

This Committee, on which the Institution is represented, was formed primarily to advise, in conjunction with the Ministry of Labour, youths of sixteen years of age just leaving Public and Secondary schools, on careers in the engineering and allied industries. The Committee is responsible for advising and finding positions for boys from 250 schools in London and South Eastern Counties. Members will realise that here is promising material for the engineering industry. Applications for particulars about likely candidates can be obtained through Headquarters or direct to the Committee, 41, Tothill Street, London, S.W.1.